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Dear Terry:

I am writing this letter to inform you about progress on our project, "PET Studies of Components of High-Level Vision" (N00014-91-J-1243). We have continued to make progress on two fronts during the last quarter.

I. PET Studies

We have been testing subjects in three PET studies during the past quarter.

Canonical and noncanonical views during object identification

We have now tested twelve subjects in an experiment in which we study how objects are identified when seen from unusual points of view. As noted in earlier quarterly reports, this study will allow us to test a prediction of Kosslyn, Flynn, Amsterdam and Wang (1990); this theory led us to expect processes in the parietal lobe (involved in shifting attention) and in the frontal lobe (involved in formulating hypotheses) to be invoked when subjects identify pictures of objects seen from an unusual point of view but not when objects are seen from canonical points of view. The subjects have participated in three conditions: 1) They see a series of pictures of objects seen from a canonical point of view; 2) they see a series of pictures of objects seen from an unusual point of view; 3) they see see random noise patterns. In all three conditions, the subjects hear a word immediately before each picture is presented. In the first two conditions, they verify whether the word names the picture; in the third (baseline) condition, they simply press a pedal when they hear the word. We are just now beginning to analyze the data. We are subtracting the blood flow evoked by this baseline task from that evoked when canonical pictures are presented, which allows us to examine the brain bases of bottom-up picture naming. In addition, we are subtracting the blood flow evoked when canonical pictures are named from that evoked when noncanonical pictures are named, which allows us to examine the brain bases of top-down hypothesis testing during visual object identification.

Imagery and retinotopic mapping

After the three conditions in the picture identification experiment, we have tested some subjects in another task. Two subjects were asked to visualize upper case letters of the alphabet, and then to decide whether the letter has any curved lines. In one condition, the subjects visualize the letters as if they are seen at a tiny size, and in another condition they visualize the letters as if they are seen at a larger size. We are finding that subjects can evaluate the "larger" images more quickly than the smaller ones, replicating results originally reported by Kosslyn (1975). This result provides convergent evidence that they are in fact following the instruction, and are varying the "size" of the imaged letters. We expect a more posterior focus of activation when the letters are visualized at a small size, compared to when they are visualized at a large size; Peter Fox and his colleagues at Washington University showed in 1976 that V1 in humans is retinotopically mapped, with the most posterior portion of the calcarine fissure representing the fovea, and more anterior regions representing increasingly more peripheral locations. Our earlier PET experiments on imagery suggest that V1 is activated during imagery. If we find evidence of topographic mapping during imagery--even when one's eyes are closed while one is forming the images--this result would be strong support for the claim that images represent information spatially.

Imagery activation and eye movements

Finally, we have tested four subjects in another imagery experiment. This one is a replication of the original imagery experiment described in previous quarterly reports, with two changes. On each trial of the original imagery condition, subjects saw a 4 x 5 grid that contained only an X mark (in one cell). The subjects visualized an upper case letter and decided whether it would cover the X mark. In contrast, on each trial of the original perception condition, subjects saw the same stimuli except an upper case letter was presented in the grid (in a light gray color) along with the X, and subjects merely evaluated what they saw. We examined the effects of imagery per se by subtracting the pattern of blood flow from the perceptual task from that obtained in the imagery task. We found that area V1, as well as several other areas, including the pulvinar, were activated more during imagery. However, it is possible that these results reflect subjects' eye movements over the empty grid. To control for this possibility, we are repeating the imagery condition but now present the grid for only 175 ms, which is not enough time to make an eye movement. In addition, we were concerned that the imagery task was more difficult than the perception one, and difficulty per se could underlie the effects (multiplying small effects in the perception condition). Thus, we have made the perception task more difficult by making the X marks dimmer. If we obtain the same results as before, it will be difficult to argue that they are due to how subjects scan the empty grids or differences in the difficulties of the tasks.

II. Off-line Preliminary Studies

We continue to perform off-line studies in preparation for additional PET studies.

The role of shape and location in object identification

We have completed four experiments with normal subjects, in preparation for future PET experiments. These experiments also tested a prediction of the Kosslyn et al. (1990) theory. According to that theory, information from the objects-properties-encoding ventral stream (presumably involving inferior temporal cortex, if the components of the human visual system are localized like those of monkeys) and the spatial-properties-encoding dorsal stream (presumably involving parietal cortex) are used to recognize an object in some circumstances. Specifically, if the input is degraded, so that the encoding of shape may not match stored information very well, then our theory predicts that spatial properties will be used to recognize the object in a constraint-satisfaction process further downstream. To test this idea, we showed subjects pictures of common objects, which were located in different places on the screen. We later asked them to view a series of pictures of objects, half of which were shown previously and half of which were not. Half of the previously seen objects were presented in their original locations, and half were not. We found that recognition time did not depend on the location of the object if it was presented in free view. However, if the object was presented only very briefly, then subjects were faster when the object appeared in its original location. A report of this research has been written and soon will be sent to you along with the revision of the Cave and Kosslyn paper on the role of parts in object recognition. We plan to administer variations of these tasks to subjects while they are being PET scanned.

Sincerely,

Stephen M. Kosslyn
Professor